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Quarterly Technical Report

No. 6329-3

on the

DEVELOPMENT OF METALLIZATION PROCESS

FSA Project, Cell and Module Formation Research Area

For the Period Ending

June 30, 1982

Contract 956205

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The Flat-Plate Solar Array Project is sponsored by the U.S. Department of Energy and forms part of the Solar Photovoltaic Conversion Program to initiate a major effort toward the development of low-cost solar arrays. This work was performed for the Jet Propulsion Laboratory, California Institute of Technology by agreement between NASA and DOE.

ABSTRACT/SUMMARY

Various Mo/Sn screen printing pastes were scheduled for evaluation. Cells are first prefired in air and then fired in a H_2 atmosphere. Preliminary results are encouraging.

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Section 1.0

INTRODUCTION

The objective of this contract is the optimization, evaluation, and demonstration of a novel metallization applied by a screen printing process. The process will be evaluated on both CZ and non-CZ silicon wafers.

Section 2.0

TECHNICAL DISCUSSION

2.1 PASTE FORMULATION

Five screen printing pastes have been prepared by Thick Film Systems, Inc. The pastes are 80-85% solids using vehicle #3347. The metal content in parts by weight follows:

Type	TFS #	Sylvania 280-325 Mo	Atlantic Equipment Engineers SN 266 Sn	Ferro Plant PX-41 TiH
A	DP-E570	19.5	80.0	0.5
B	DP-E571	50.0	49.5	0.5
C	DP-E572	70.0	29.5	0.5
D	DP-E573	49.0	49.0	2.0
E	DP-E574	48.0	48.0	4.0

2.2 CELL MANUFACTURE

The process for cell manufacture was fixed at the start of the program up to the front printing step. Figure 1 shows the traveler that was used.

Wafers were bought from Smiel. The wafers are 3.0" round, 15 mils thick, 7-14 Ω-cm, 1-0-0, Type P silicon.

Cell preparation begins with a 30% NaOH etch followed by phosphine diffusion. Al paste is then screen printed on the back and fired

CELL MANUFACTURING

PRODUCTION LOT NO: ____________________

START DATE: ______________

Silicon	
Manf -	Resist -
Type -	PO #
Orient -	Size -
Thickness-	Series # -

OPERATION		DATE	OPERATOR	NO. OF CELLS START	GOOD	BAD	REASON FOR REJECTION	
SURFACE PREPARATION								
DIFFUSE								
PRINT AL BACK								
FIRE AL BACK								
CLEAN BACK								
LASER SCRIBE								
PRINT								Screen - Paste -
PREFIRE								Furnace - Gas -
PREFIRE								Furnace - Gas -
FIRE								Furnace - Gas -
FIRE								Furnace - Gas -
FIRE								Furnace - Gas
FIRE								Furnace - Gas -
TEST								
AR COAT								
TEST								

Figure 1

CELL TRAVELER FOR METALLIZATION PROGRAM

to form the P+ layer. The backs are cleaned and a 2.1" x 2.1" square wafer is laser-scribed out of the round wafer. These squares are then ready for front metallization printing.

2.3 PASTE EVALUATION

Type A paste was used exclusively for the initial evaluations. Procurement problems forced the use of a round front metallization pattern on a square wafer. This pattern led to high series resistance. Screen printed silver cells were used as controls. The IV curve for the best silver cell is shown in Figure 2. This cell has no AR coating. The shunt resistance was measured at 0.5V reverse and found to be 25.0Ω.

The first parameters used for evaluation were a prefire in an IR belt furnace followed by firing in a 5% H_2/95% N_2 atmosphere. Cells were prefired at 500°C at various belt speeds and then fired for 3 minutes in the reducing atmosphere for 30 minutes. The cells showed poor IV curve caused by shunting and high series resistance.

A second experiment tried 450° and 500° prefires followed by shorter firing times and 650°C. These cells were also poor.

Next, firing was tried in a 100% H_2 atmosphere. Cells showed metallic-like contacts similar to silver contacts. Curve shape improved.

The next experiment followed the matrix shown in Table 1.

The best cells are those fired at 575° for 1 minute. Prefiring at 18"/minute seems slightly better than 9"/minute. Figures 3 and 4 are IV curves of the best two cells. Table 2 shows the

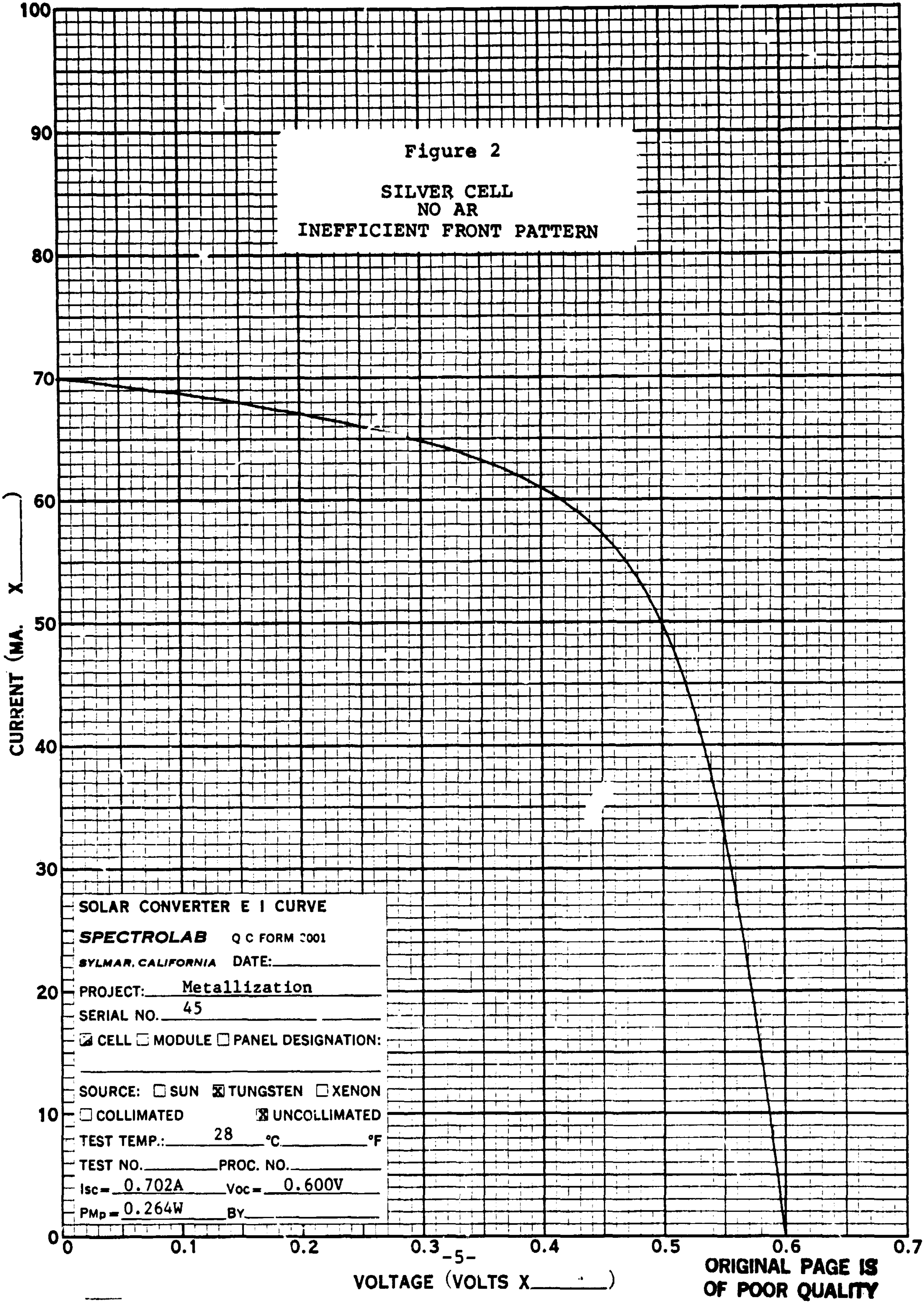

Figure 2

SILVER CELL
NO AR
INEFFICIENT FRONT PATTERN

Table 1

Prefire	18"/min. 500°	9"/min. 500°	
Fire	30 secs.	30 secs.	600°
	1 min.	1 min.	
	2 min.	2 min.	
	5 min.	5 min.	
	1 min.	1 min.	575°
	1 min.	1 min.	550°
	1 min.	1 min.	525°

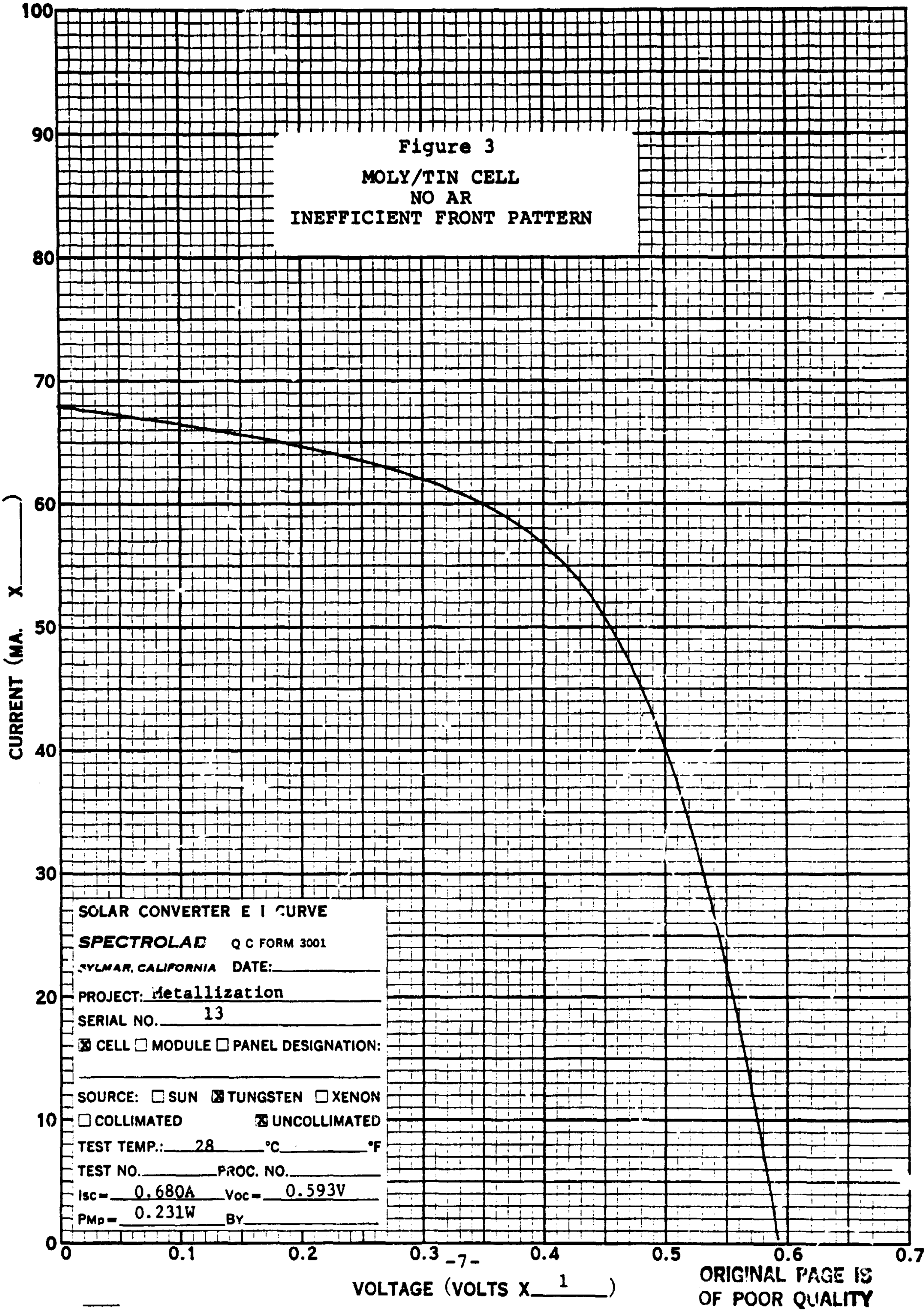

Figure 3
MOLY/TIN CELL
NO AR
INEFFICIENT FRONT PATTERN

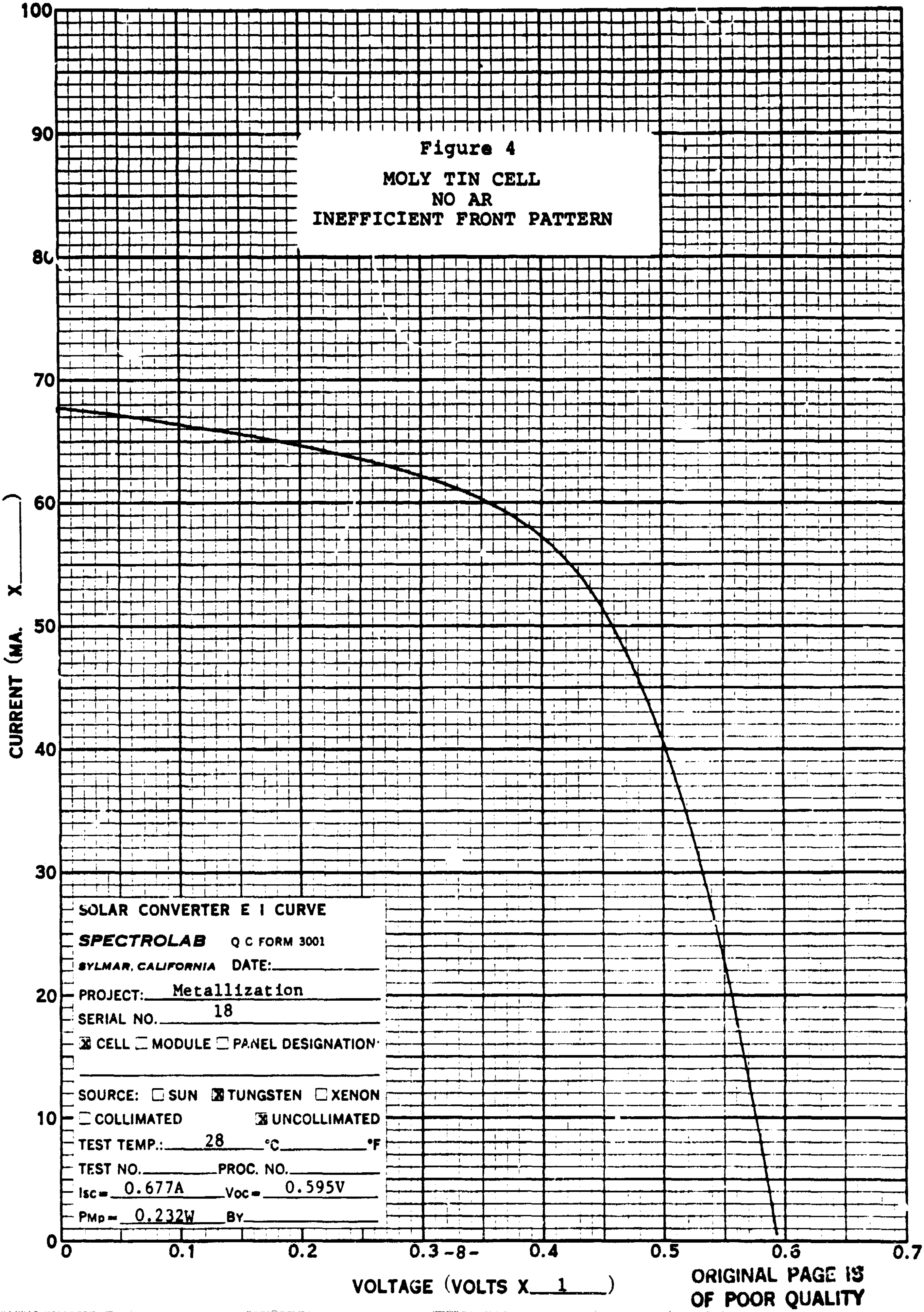

Figure 4
MOLY TIN CELL
NO AR
INEFFICIENT FRONT PATTERN

Table 2

SUMMARY OF CELL CHARACTERISTICS

Cell #	I_{sc}	V_{oc}	I_{500}	I_{mp}	V_{mp}	P	FF	E	(If AR)	R_{shunt}
13 (Mo/Sn)	680	593	409	54[illegible]	427	.231	.573	8.12	(10.7)	39.7
18 (Mo/Sn)	677	595	411	543	428	.232	.576	8.15	(10.8)	61.7
45 (Ag)	702	600	501	579	463	.264	.627	9.28	(12.3)	25.0

characteristics of these cells compared to the silver controls. The cells have not been AR coated and the AR efficiencies are based on a 32% gain.

The shunt resistance of the Mo/Sn cells is higher than that of silver. This indicates it may be possible to make Mo/Sn metallized cells that are superior to AG cells, if the series resistance problems are overcome.

Section 3.0

CONCLUSIONS AND RECOMMENDATIONS

There are no conclusions or recommendations for this period.

Section 4.0

ACTIVITIES PROJECTION

More cells will be fabricated using the Type A paste. Other pastes will be evaluated. Interconnection tests will be run to determine metallization adherence. A milestone and delivery schedule follows.

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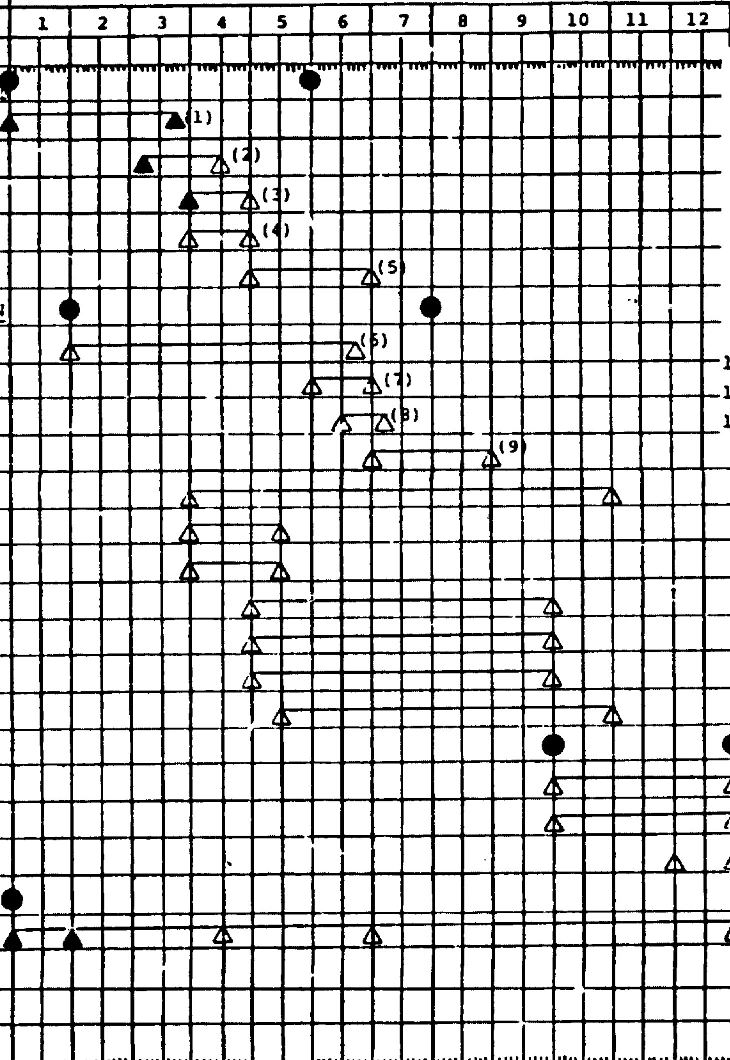
MILESTONE CHART AND DELIVERY SCHEDULE

SHEET 1 OF 2
DATE 9/18/81
REVISION

ITEM OR TASK	DESCRIPTION
10	OPTIMIZATION OF FRONT METALLIZATION
11	First Metallization Form.
12	Second Metallization Form.
13	Interconnections of Cells
14	Prototype Cells
15	Demonstration Run
20	OPTIMIZATION OF BACK METALLIZATION
21	Metallization Formulation
22	Interconnection of Cells
23	Prototype Cells
24	Demonstration Run
30	ENVIRONMENTAL OPERATIONAL TESTING
31	Cell Characterization
32	Adhesion Test
33	Humidity Degration Test
34	Contact Resistivity Test
35	Current Capacity Test
36	Combined Tests
40	METALLIZATION APPLIED TO NON-CZ WAFERS
41	Applied to Baseline Sequence A
42	Applied to Baseline Sequence B
43	Demonstrate Process
50	PROGRAM MANAGEMENT
51	Management (Des. Rev./PIM/Other)
52	Deliverables:



MILESTONES IDENTIFIED

1) First set of front metallizations evaluated
2) Final front metallization selected
3) Front soldering process finalized
4) Front metallization prototype cells fabricated
5) Demonstration of front metallization completed
6) Final back metallization selected
7) Back soldering process finalized
8) Back metallization prototype cells fabricated
9) Demonstration of back metallization completed
10) Metallization testing completed
11) Metallization applied to Baseline Sequence A
12) Metallization applied to Baseline Sequence B

LEGEND

NOTES

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PROGRAM METALLIZATION PROCESS

Q- 81451

SPECTROLAB a subsidiary of Hughes Aircraft Co	MILESTONE CHART AND DELIVERY SCHEDULE	SHEET 2 OF 2 DATE 5/3/82 REVISION 1

ITEM OR TASK	DESCRIPTION	1	2	3	4	5	6	7	8	9	10	11	12	
	Software:													
	Program Plan	▲ ▲												
	Monthly - Technical		▲	▲		△	△		△	△		△	△	
	Monthly - Financial		▲	▲	▲	△	△	△	△	△	△	△	△	
	Quarterly - Technical				▲			△			△			
	Final													FINAL △ △ DRAFT
	Documentation Specification							△						
	Economic Evaluation							△						
	Hardware:													
	Cells from Subtasks 14 and 23										△			
	Cells from Subtasks 15 and 24												△	
	Task 40 Demo Run Cells													△
	Contract Funded Equipment													△

LEGEND

NOTES

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PROGRAM METALLIZATION PROCESS

Q-81451

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